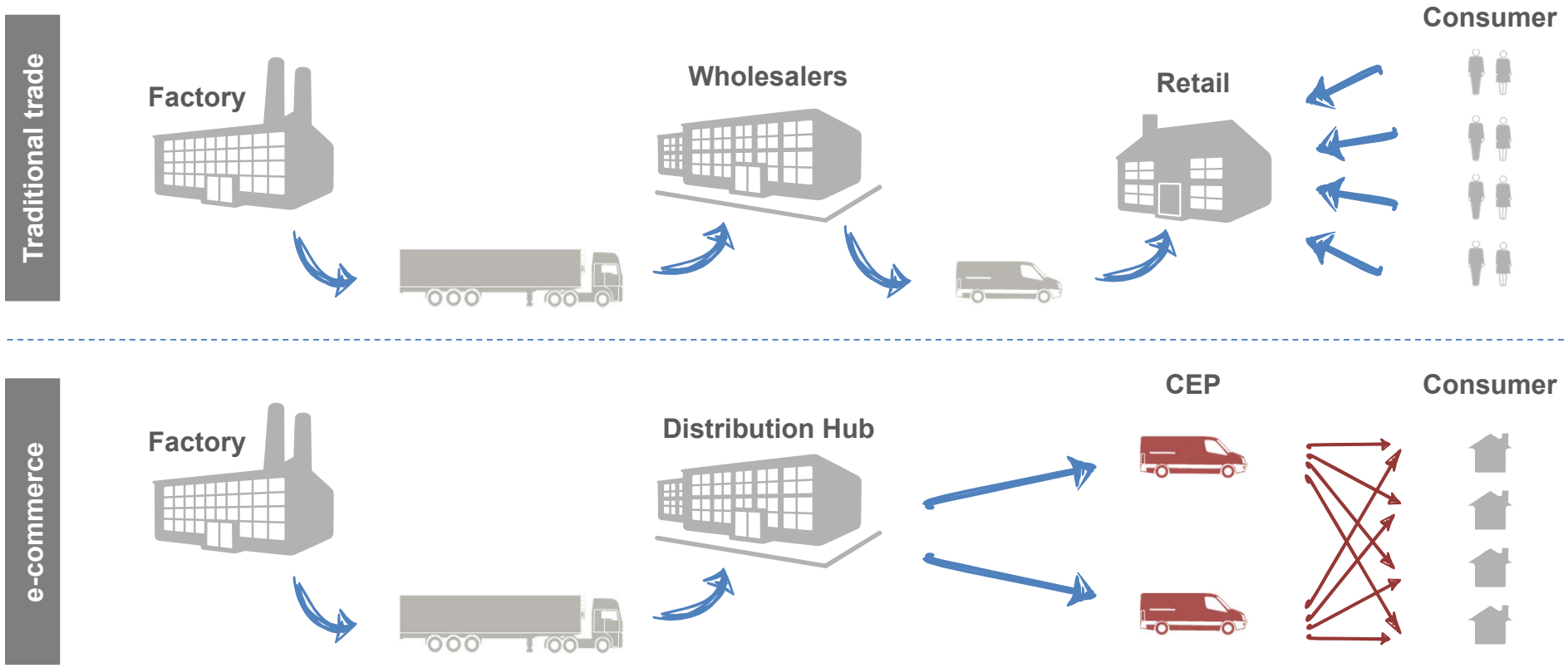
23th European Fuel Cell Forum – EFCF 2019, 02 – 05 July 2019, Lucerne (CH)

# Fuel cell technology adapted for cargo pedelecs

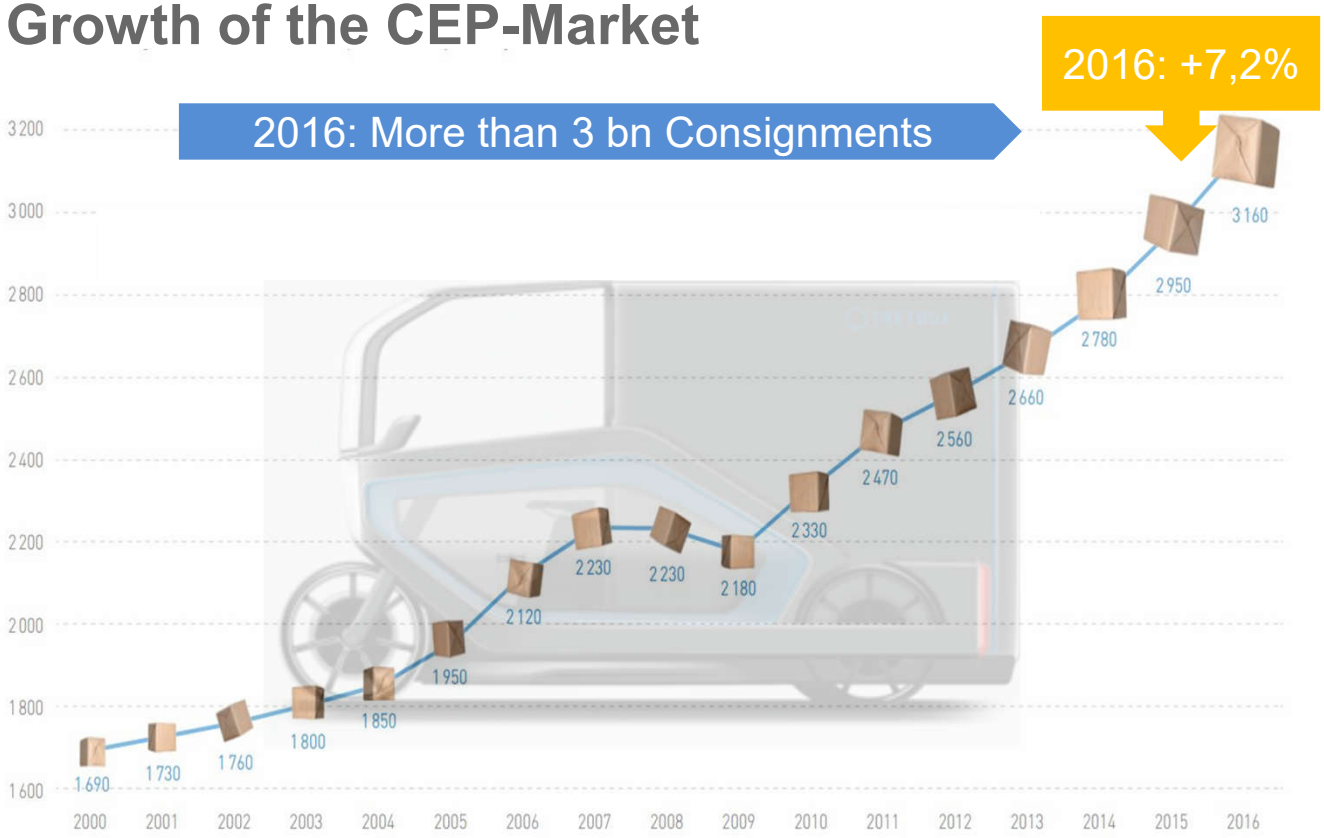
T. Knöri, M. Schulze, I. Bürger, T. Maag


DLR

# E-commerce has disrupted Trade related Supply Chains …



# Growth of the CEP-Market




Shipment Capacity in the german CEP-Market (2000 – 2016)

Source: KEP-Studie 2016, Befragung der KEP-Unternehmen 2017, KE-CONSULT Marktanalyse

**In Germany:**

- **3,16 bn Shipments 2017**
- **Delivered by 60.000 Vehicles**

**Until 2028:**

- **11.400 Fuel Cell Cargo Pedelecs**
- **(22.800 in Europe)**

# … and caused several logistic related Challenges

## Growing Emissions


**~50% of air pollutant emissions**
are related to transport activities[1]

## More Traffic Jams

**~30% of vehicle kilometers**
stem from transportation[1]

## Delivery Delays

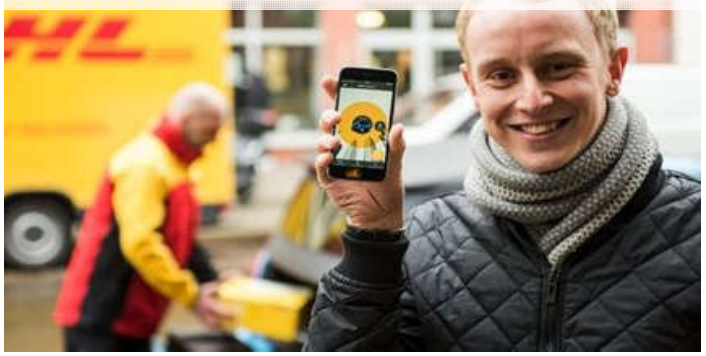
**~70% of all deliveries**
get stuck on the last mile[1]

1. In major German cities

# Alternatives for Last Mile Delivery already being explored by CEP Providers

Parcel delivery robots


Car trunk delivery



Unmanned aerial vehicles (UAVs)



Parcel stations


Cargo pedelecs (CPs)

# Cargo Pedelecs bear the Potential to address the identified Challenges

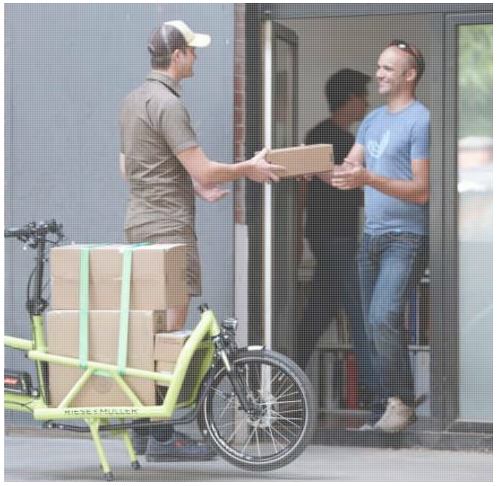
### Zero (local) emissions


**Pedaling power** supported by electric propulsion system instead of combustion engine

### Reduced congestions

**Broader utilization** of urban infrastructure (bike/bus lanes, parks, pedestrian areas)

### Faster delivery



**Higher average speed** of CPs on the last mile compared to vans

**Key to success of Cargo Pedelecs are a suitable energy source and a tailored logistic concept**

# FCREX - A compact Fuel Cell Module for Cargo Pedelecs


**Range**

- **FCREX fuel cell system** provides **5 kWh electric energy**
- **Twice the range** vs. battery at same size due to higher energy density

**Fueling**

- **FCREX** can be **refueled within minutes**
- Hydrogen **infrastructure available** in key markets and steadily growing

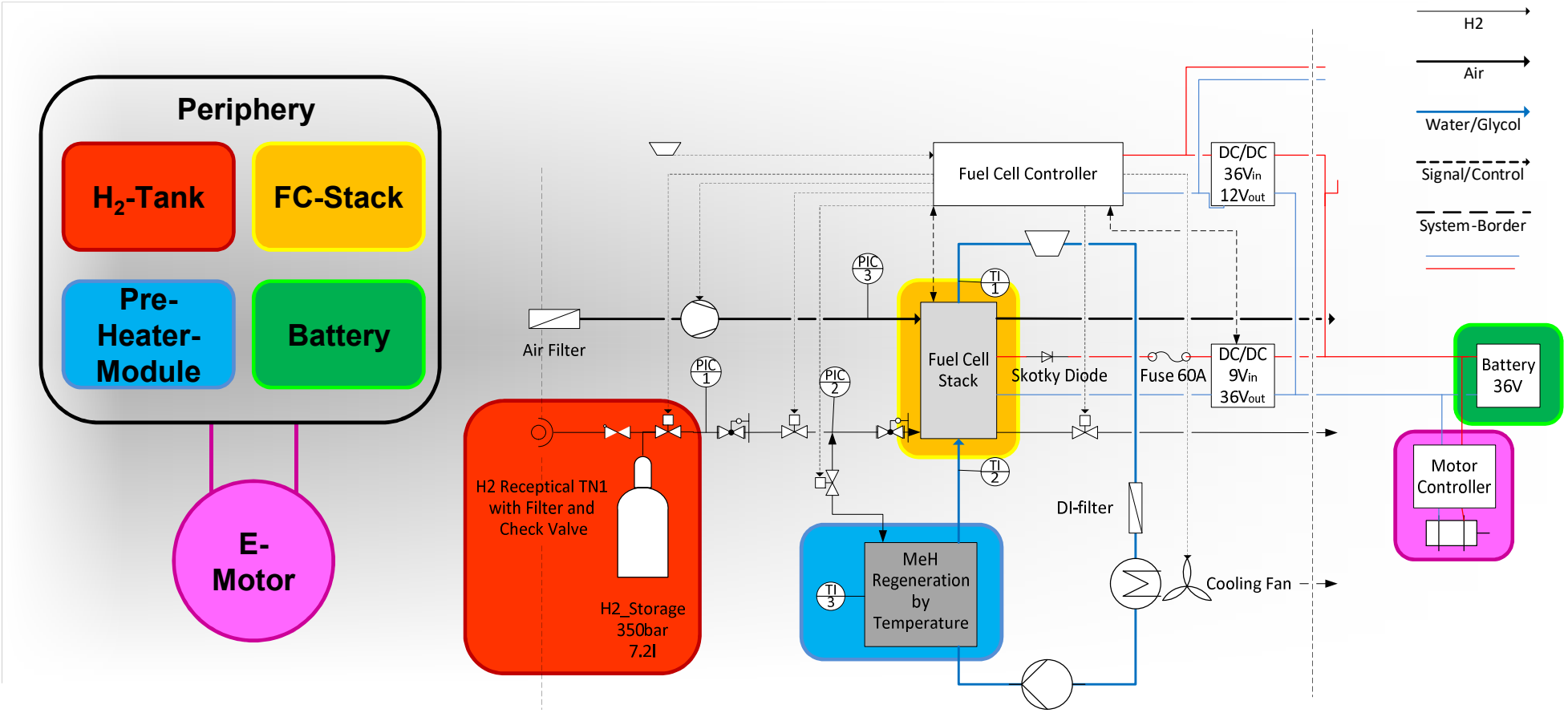
**Low Temperature**

- **FCREX** equipped with **modular pre-heater**
- System can be operated **down to -20°C** without performance losses

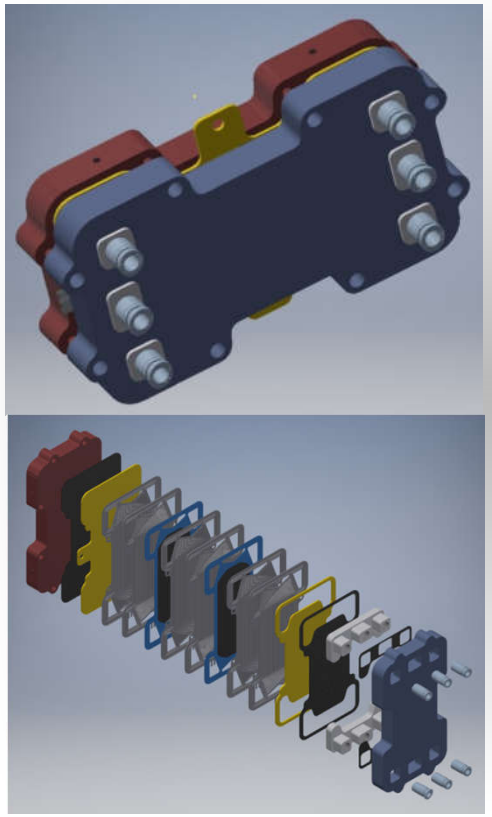
**Heating**

- **FCREX** emits **thermal energy for heating**
- Heat stems from **exothermic reaction** - No impact on range

# What is inside the box? FCREX – Basic Set-Up



# What is inside the box? FCREX – Fuel Cell Stack



- Compact FC system for light electric vehicles (LEVs), **max output ~ 750W**
  - **Metallic bipolar plates** ensure high durability in tough operating conditions
    - Stack consists of **20 cells** with **~ 60 cm² active area** per cell
    - Stack **dimensions ~ 215 x 120 x 117 cm**, stack **weight ~ 2000 g**
  - Minimum **output voltage 13 V,** maximum **current 60 A**
- **Liquid-cooling** to extend **life span** and improve **cold starting** capabilities

# Special feature: FCREX pre-heating system with no extra $H_2$ consumption


- Pre-heating system **enables frost / cold start** and **reduces degradation**
- Based on **metal hydride powder** material - **no extra $H_2$ consumption**
- Starts immediately from **-20 °C**, preheating to **5 °C in < 3 minutes**
- **Integrated heat transfer structure** and **minimal amount of fluid**
- Aluminum **one-piece-design**, **additive manufacturing**, **patent pending**
- Performance | $P_{peak}$ **= 1 kW/kg$_{MH}$ or 0.3 kW/kg$_{Sys}$**

Photos/drawings: C. Kretschmer, MA, 2019

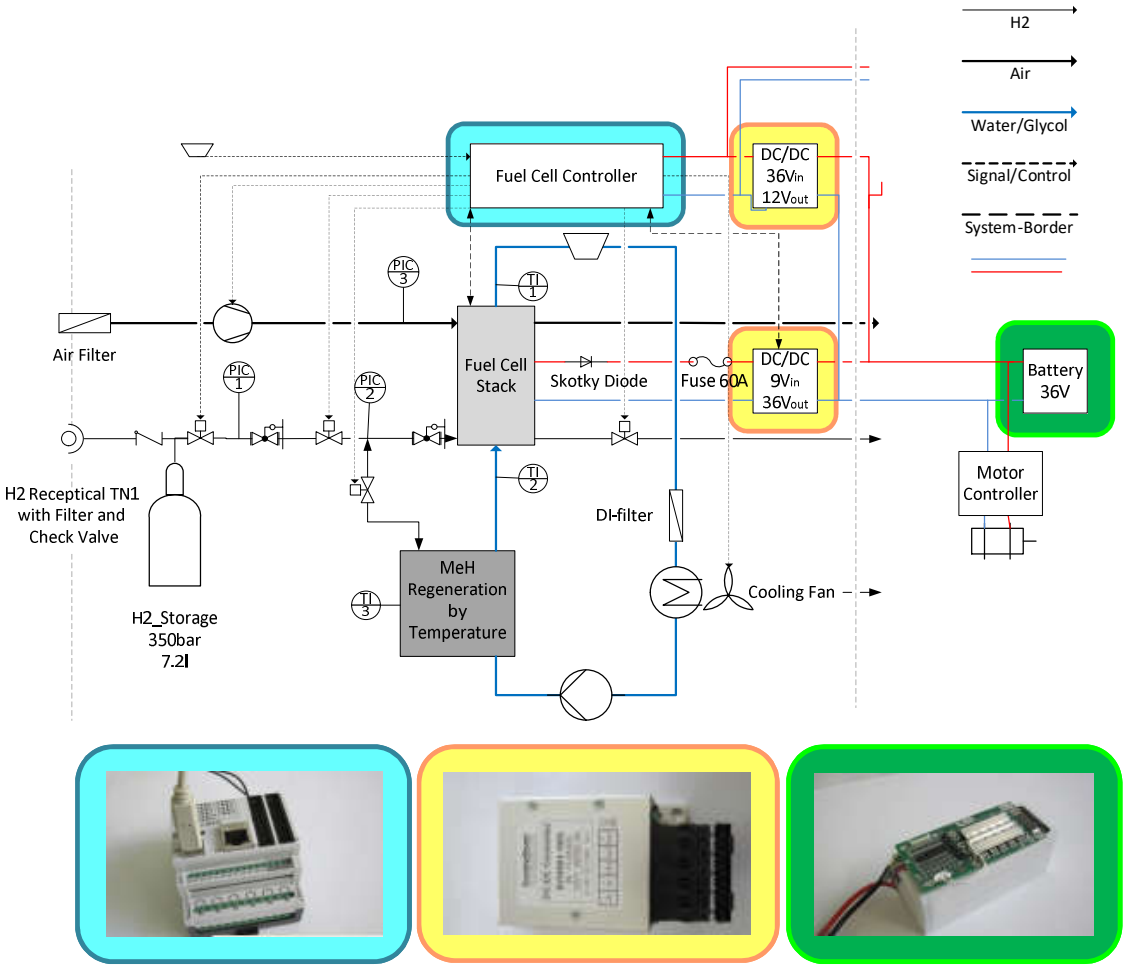
# What is inside the box? – Battery & Controlling System

**Infrastructure electric:**

- Battery: LiFePO4 36V/2,3Ah incl. BMS
- Control system: Controllino Automation, industry-grade PLC with Arduino compatibility
- DC/DC-Converter: Compact onboard charge controller for different fuel cells and hybrid batteries incl. constant main voltage

**Infrastructure process engineering:**

- Air supply: blower, filter
- Hydrogen supply: Pressure reducers, valves, connectors
- Fluid cooling supply: fluid pump, thermostat-valve, deionizer filter



# FCREX is our Solution to power the next Generation of Cargo Pedelecs


- Cargo pedelecs feature a **payload up to 400 kg**
- Freight compartment provides **storage space of 0.5 -1.5 $m^3$**
- **FCREX** can be easily fitted into **any cargo pedelec designs**
- **FCREX** compatible with **existing $H_2$ pressure tanks**
- **FCCP lightweight tank** (Under preparation)

# Interreg Projekt FCCP (Fuel Cell Cargo Pedelec)

## I. Technology Validation

Validation of the FCREX (Fuel Cell Range Extender) with 50 cargo pedelecs under different commercial, topographic and climatic operating conditions

## II. Logistic Concept

Development of logistic concepts which are specially adapted to the performance characterics of the FCREX-powered cargo pedelecs

## III. Measure Catalogue for Municipalities

Categorisation and assessment of municipal actions for supporting the integration of FCCP into local supply chains

## Acknowledement FCCP

This FCCP (Fuel Cell Cargo Pedelec) project has received funding from the Interreg North-West Europe under NWE596 in the program Priority Axis2 Low Carbon, specific objective SO4.

# Thank you for your Attention!

Torsten Knöri
torsten.knoeri@dlr.de
German Aerospace Center
Stuttgart, Germany